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(54) **ELECTRIC AND MAGNETIC FIELD HARDENED IGNITER FOR ELECTRICALLY FIRED AMMUNITION**

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F42B 5/08 (2006.01)
F42B 3/11 (2006.01)

(52) **U.S. Cl.**
CPC . ***F42B 5/08*** (2013.01); ***F42B 3/103*** (2013.01); ***F42B 3/11*** (2013.01)

(58) **Field of Classification Search**
CPC F42B 3/11; F42B 3/124; F42B 3/128; F42B 3/14; F42B 3/103; F42B 3/12
USPC 102/202.5, 202.7, 202.8, 202.9, 202.14
See application file for complete search history.

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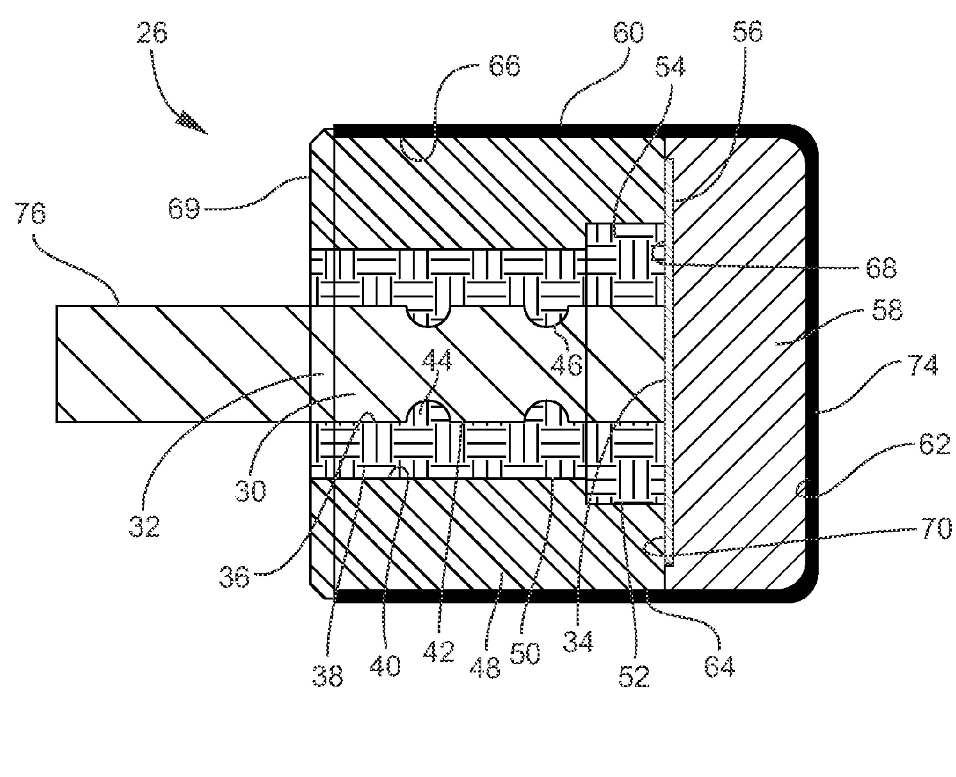
(57) **ABSTRACT**

An EMF hardened igniter for electrically fired ammunition includes a central electrode, a dielectric that surrounds the central electrode, and a conductive body that surrounds the dielectric. A hot wire is fixed to an output end of the central electrode and to the conductive body. An ignition mixture is in contact with the hot wire. A cup surrounds and contains the ignition mixture. The cup is sealed to the conductive body. An outer surface of the central electrode is mechanically locked with an inner surface of the dielectric. An outer surface of the dielectric is mechanically locked with an inner surface of the conductive body.

18 Claims, 3 Drawing Sheets



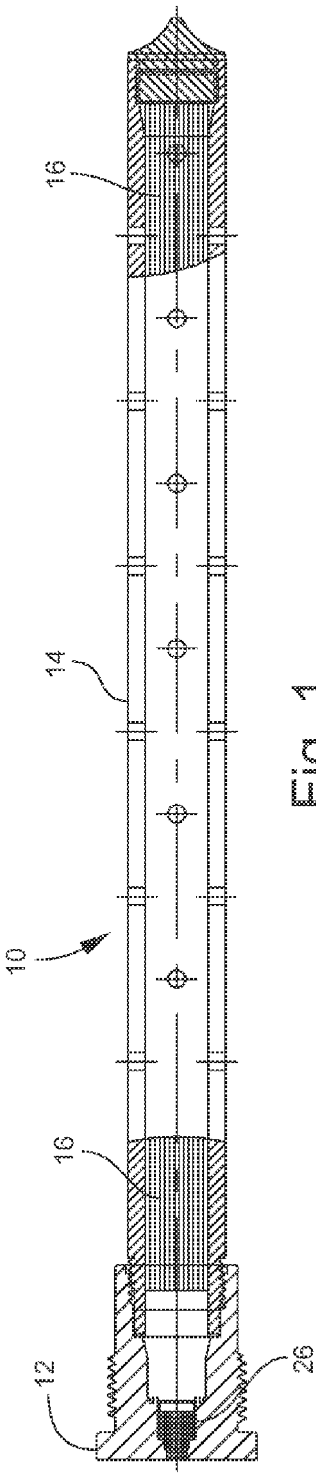


Fig. 1

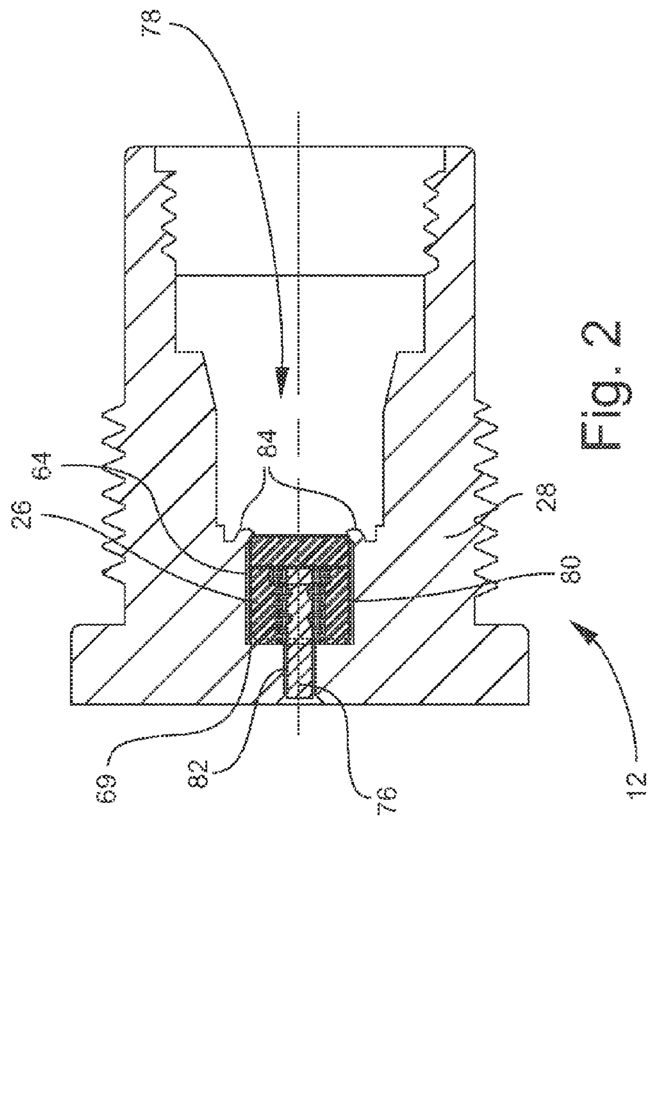


Fig. 2

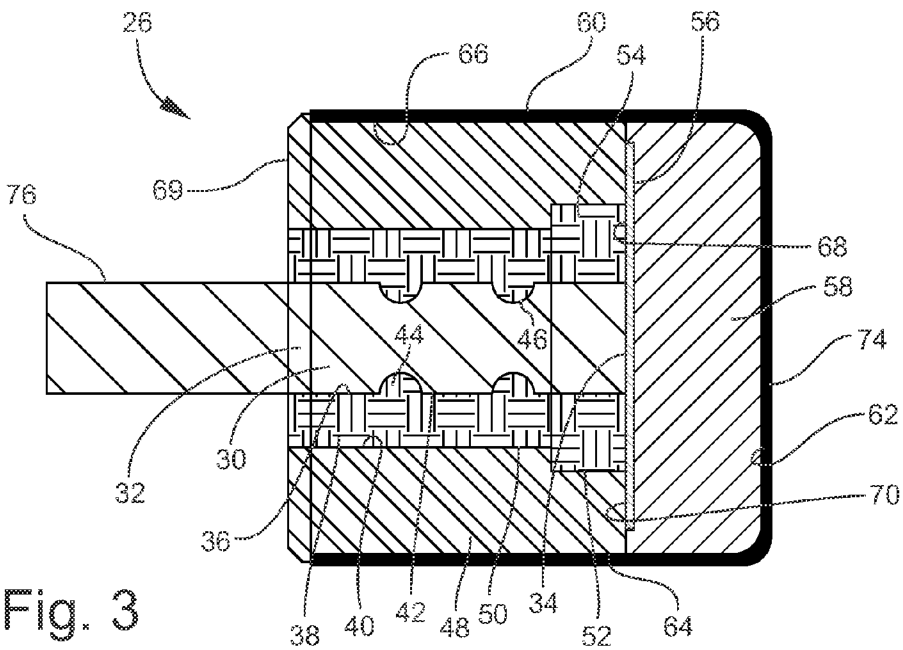


Fig. 3

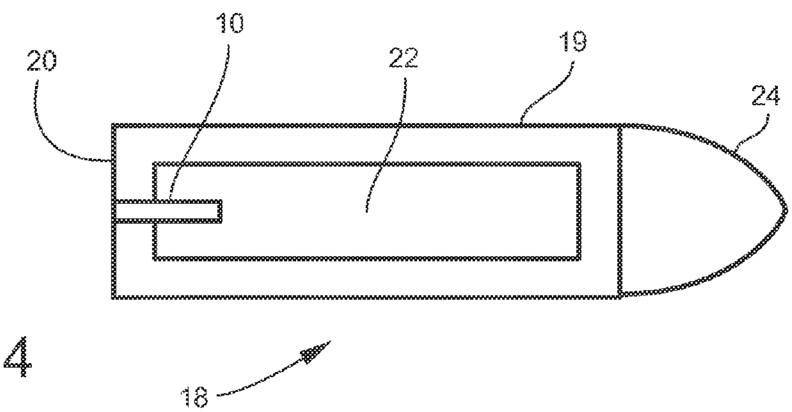


Fig. 4

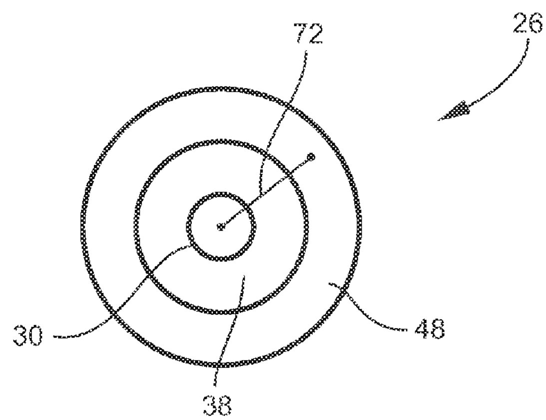


Fig. 5

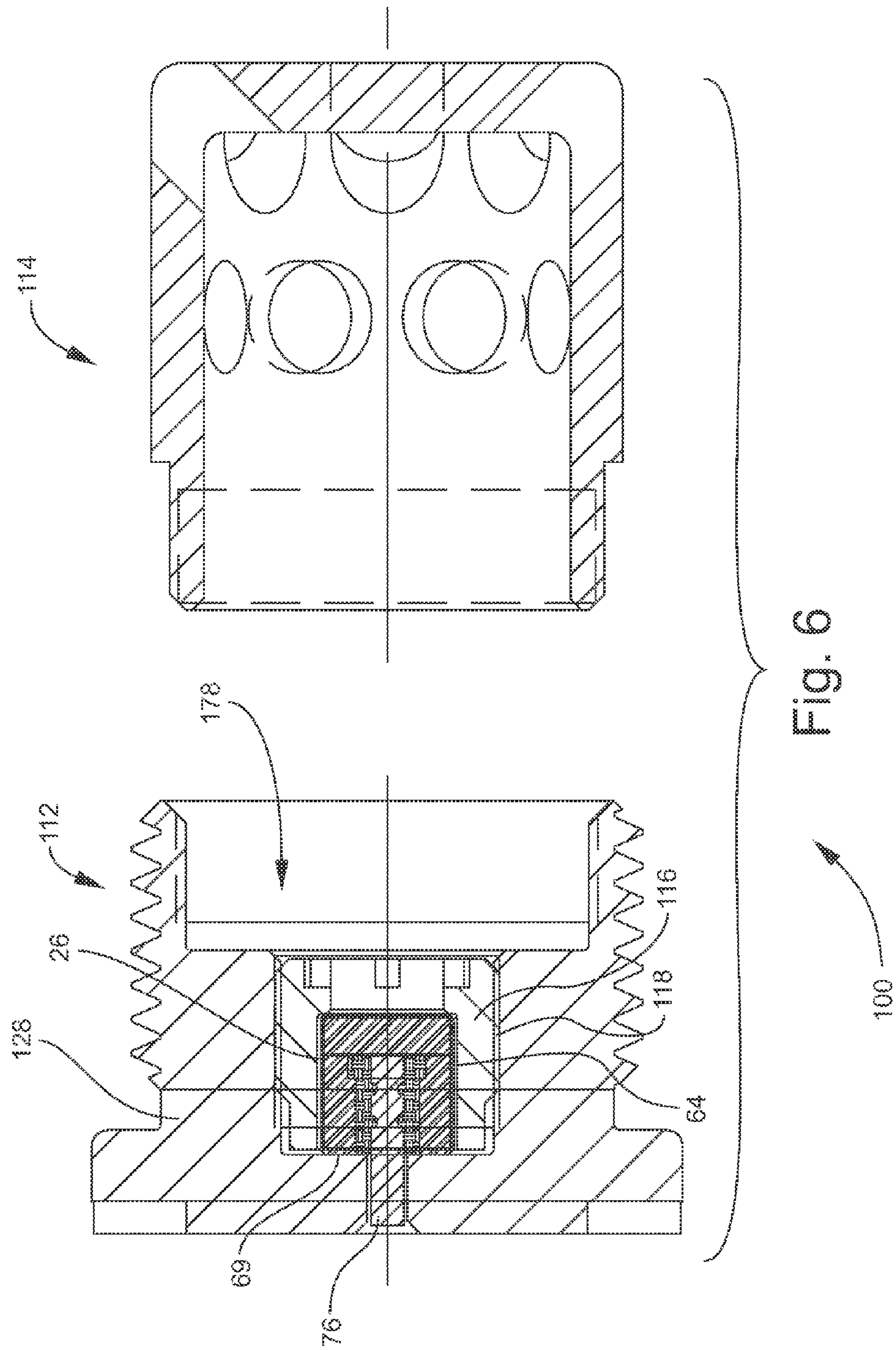


Fig. 6

ELECTRIC AND MAGNETIC FIELD HARDENED IGNITER FOR ELECTRICALLY FIRED AMMUNITION

STATEMENT OF GOVERNMENT INTEREST

The inventions described herein may be manufactured, used and licensed by or for the United States Government.

BACKGROUND OF THE INVENTION

The invention relates in general to electrically fired ammunition and in particular to igniters for electrically fired ammunition.

Electrically fired ammunition may use an electrical current to ignite a primer, and the primer may then ignite the main propellant charge in the round of ammunition. Electrically tired ammunition may be stored and transported in packaging containers that help prevent the ammunition from undesirably initiating in the presence of electromagnetic fields (EMFs). When the ammunition is outside of the packaging containers, there are restrictions on handling the ammunition in the presence of certain EMFs. Tests have shown that some radio-generated EMFs may initiate the ammunition, causing adverse consequences. This problem has existed for many years, but recent research has more precisely recognized the cause of the problem.

The increase in radio technology used in military operations generates a higher risk of unintended initiation during routine loading and handling of electrically fired ammunition. In the past, the ammunition was either packaged in metal cans or sealed in ammunition storage compartments to protect the ammunition from EMF initiation. Unfortunately, neither of these options lessens the risk during loading and handling operations when the ammunition is not in the cans or storage compartments. One available technology to address the problem is grounding tabs. However, the grounding tabs must be removed before the ammunition can be fired. Grounding tabs can be inadequate and unacceptable because of the potential of a misfire caused by failure to remove the grounding tabs. Many concepts have been tested, but none appear to be able to withstand the extreme pressure of the ballistic cycle of a cannon/gun system, while also providing EMF protection. The ballistic pressure may be on the order of 100,000 psi.

A need exists for an igniter for electrically fired ammunition that is hardened against EMF and able to survive the ballistic cycle in a gun/cannon environment. The EMF hardened igniter should not degrade the performance of the ammunition nor require changes in ammunition handling and operational procedures.

SUMMARY OF INVENTION

One aspect of the invention is a novel igniter for electrically fired ammunition. The igniter includes a central electrode, a dielectric, a conductive body, at least one hot wire, an ignition mixture, and a cup. The central electrode has an input end, an output end, and an outer surface. The dielectric surrounds the central electrode and has an outer surface and an inner surface. The dielectric inner surface is contiguous to the outer surface of the central electrode. The outer surface of the central electrode and the inner surface of the dielectric are fixed to each other by at least one mechanical lock. The conductive body surrounds the dielectric and has an inner surface that is contiguous to the outer surface of the dielectric.

The inner surface of the conductive body and the outer surface of the dielectric are fixed to each other by at least one mechanical lock.

The at least one hot wire is fixed at one end to the output end of the central electrode and at another end to the conductive body. The ignition mixture in contact with a majority of surface area of the at least one hot wire. The cup surrounds and contains the ignition mixture. The cup has an inner surface that is contiguous to the ignition mix. The cup is fixed to the conductive body.

The central electrode may have a generally cylindrical shape. The dielectric may have a generally hollow cylindrical shape. The conductive body may have a generally hollow cylindrical shape.

The at least one hot wire may be parallel to a plane that contains the output end of the central electrode.

The dielectric may include an output end and the conductive body may include an output end. The hot wire may be in contact with the output end of the central electrode, the output end of the dielectric and the output end of the conductive body.

The cup may include a bottom and a side. The bottom may be parallel to the plane that contains the output end of the central electrode. The cup may be fixed to the conductive body by welding the side of the cup to the conductive body.

The hot wire may be welded to the output end of the central electrode and the output end of the conductive body.

The at least one mechanical lock that fixes the outer surface of the central electrode and the inner surface of the dielectric may include protrusions on the inner surface of the dielectric and corresponding mating circumferential channels in the outer surface of the central electrode.

The at least one mechanical lock that fixes the outer surface of the dielectric and the inner surface of the conductive body may include a stepped down portion on the inner surface of the conductive body and a corresponding mating stepped up portion on the outer surface of the dielectric.

Another aspect of the invention is a novel primer head assembly. The primer head assembly includes a primer housing and an igniter disposed in the primer housing.

In another aspect of the invention, a novel electric primer includes a primer head assembly and a primer body assembly fixed to the primer head assembly.

In a further aspect of the invention, a novel electrically fired munition includes a case with a base, an electric primer disposed in the base, and propellant disposed in the case.

The invention will be better understood, and further objects, features and advantages of the invention will become more apparent from the following description, taken in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

In the drawings, which are not necessarily to scale, like or corresponding parts are denoted by like or corresponding reference numerals.

FIG. **1** is a side view, partially in section, of one embodiment of an EMF hardened electric primer.

FIG. **2** is an enlarged sectional view of the primer head assembly shown in the primer of FIG. **1**.

FIG. **3** is an enlarged sectional view of the igniter shown in the primer head assembly of FIG. **2**.

FIG. **4** is a schematic side view of an example of an electrically fired munition.

FIG. **5** is a schematic top view of an igniter with cup and ignition mix removed, showing one alternative arrangement of a hot wire.

FIG. **6** is a side sectional view of another embodiment of an EMF hardened electric primer.

DETAILED DESCRIPTION

A novel EMF hardened igniter may be used with a range of electrically fired ammunition calibers, for example, from about 20-40 mm to about 105-155 mm. "EMF hardened" means the igniter can withstand a higher EMF environment without igniting the ignition mix in the igniter.

One important feature of the igniter is a heat sink that transfers heat induced by EMFs away from the hot wire in the igniter. Other important features of the igniter are the mechanical connections between the components of the igniter. The mechanical connections remain intact under very high pressure, for example, 100,000 psi. The self-contained, hermetic seal of the igniter is an important feature, also. The interior of the igniter is sealed independently of the munition in which the igniter may be used.

FIG. **1** is a side view, partially in section, of one embodiment of an EMF hardened electric primer **10**. Primer **10** may include a primer head assembly **12** and a primer body assembly **14**. Body assembly **14** may be threaded into head assembly **12**. Body assembly **14** may include propellant **16**. Primer head assembly **12** includes an EMF hardened igniter **26**. Primer **10** may be installed in the base **20** (FIG. **4**) of an electrically fired munition **18**. Igniter **26** ignites propellant **16** in primer **10**, thereby igniting propellant **22** contained in case **19** of munition **18** and propelling projectile **24**. Primer **10** is but one example of an electric primer in which igniter **26** may be used.

FIG. **2** is an enlarged sectional view of primer head assembly **12**. Assembly **12** includes a housing **28** with igniter **26** disposed therein. Primer head assembly **12** is but one example of a primer head assembly in which igniter **26** may be used.

FIG. **3** is an enlarged sectional view of igniter **26**. Igniter **26** includes a central electrode **30** having an input end **32**, an output end **34**, and an outer surface **36**. Central electrode **30** may be generally cylindrical. A dielectric **38** surrounds central electrode **30**. Dielectric **38** has an outer surface **40** and an inner surface **42**. Inner surface **42** is contiguous to outer surface **36** of central electrode **30**. Dielectric **38** may have the general shape of a hollow cylinder. Dielectric **38** may be made of, for example, glass, ceramic, or polymer. Dielectric **38** may be formed by, for example, molding, sintering, machining, extruding, etc.

Axial translation of central electrode **30** with respect to dielectric **38** is prevented by a mechanical lock(s) formed on one or both of outer surface **36** of central electrode **30** and inner surface **42** of dielectric **38**. The mechanical locks also provide a high pressure gas seal between central electrode **30** and dielectric **38**. In the embodiment shown, the mechanical locks are protrusions **44** formed on dielectric **38** and corresponding mating circumferential channels **46** formed in central electrode **30**. Protrusions **44** and channels **46** are an example of a suitable mechanical lock. Other types of mechanical locks may be used to prevent axial translation of central electrode **30** with respect to dielectric **38**. Some other examples of mechanical locks for outer surface **36** and inner surface **42** include notches of various shapes, stepped features, scoring, knurling, etc.

An electrically conductive body **48** surrounds dielectric **38**. Conductive body **48** may have the general shape of a hollow cylinder. Conductive body **48** has an inner surface **50** that is contiguous to outer surface **40** of dielectric **38**. Axial translation of conductive body **48** with respect to dielectric **38** is prevented by a mechanical lock(s) formed on one or both of outer surface **40** of dielectric **38** and inner surface **50** of conductive body **48**. The mechanical locks also provide a high pressure gas seal between conductive body **48** and dielectric **38**.

In the embodiment shown, the mechanical lock is a stepped down (less radial thickness) portion **52** on conductive body **48** and a corresponding mating stepped up (more radial thickness) portion **54** on dielectric **38**. During operation of igniter **26**, high pressure gas acts on igniter **26** with the force vector of the high pressure gas pointing to the left, in the orientation of igniter **26** shown in the Figures. Thus, stepped up portion **54** is pressed into body **48**. Stepped down portion **52** and stepped up portion **54** is an example of a suitable mechanical lock. Other types of mechanical locks may be used to prevent axial translation of conductive body **48** with respect to dielectric **38**. Some other examples of mechanical locks for outer surface **40** of dielectric **38** and inner surface **50** of conductive body **48** include notches of various shapes, stepped features, scoring, knurling, etc.

At least one hot wire **56** is fixed at one end to output end **34** of central electrode **30** and at another end to conductive body **48**. An ignition mixture **58** is disposed such that it is in contact with a majority of the surface area of hot wire **56**. Ignition mixture **58** must maintain intimate contact with hot wire **56**. A cup **60** surrounds and contains ignition mixture **58**. Cup **60** has an inner surface **62** that is contiguous to ignition mix **58**. Cup **60** is fixed to conductive body **48** by, for example, welding the side **64** of cup **60** to an outer surface **66** of conductive body **48**. Ignition mixture **58** may be, for example, pressed into cup **60**.

Some ignition mixtures used in the past include, for example, lead thiocyanate or zirconium potassium chlorate (ZPC), having an auto-ignition temperature in a range of about 190 degrees C. to about 210 degrees C. An ignition mixture **58** with a higher auto-ignition temperature can be helpful in hardening igniter **26** against EMF. In one embodiment, ignition mixture **58** may be zirconium potassium perchlorate (ZPP). ZPP may have an auto-ignition temperature of around 350 degrees C. Another advantage of using ZPP is the elimination of environmentally hazardous lead from the ignition mixture.

In operation, hot wire **56** is desirably heated when a firing pulse is delivered from the firing pin of a cannon or gun through central electrode **30**. But, when a firing pulse is not delivered from a firing pin, hot wire **56** may nevertheless be undesirably heated by local EMFs. Conductive body **48**, dielectric **38**, and central electrode **30** function as a heat sink to transfer heat away from hot wire **56**. Preferably, hot wire **56** is a linear wire that is parallel to a plane that contains output end **34** of central electrode **30**. Dielectric **38** includes an output end **68** and conductive body **48** includes an output end **70**. Hot wire **56** is preferably in contact with output end **34** of central electrode **30**, output end **68** of dielectric **38** and output end **70** of conductive body **48**.

Hot wire **56** may take several forms. As shown in FIG. **3**, hot wire **56** may be a single wire that is welded to at least both central electrode **30** and at each end to conductive body **48**. FIG. **5** is a schematic top view of igniter **26** with cup **60** and ignition mixture **58** removed, showing one alternative arrangement of a hot wire **72**. Hot wire **72** has one end welded to central electrode **30** and another end welded to conductive body **48**. Additional hot wires **72** may be added, similar to the appearance of spokes on a wheel. In general, the greater the combined length of all the hot wire(s) in igniter **26**, the less sensitive is igniter **26** to EMF.

Preferably, an exterior surface of the bottom **74** of cup **60** includes a cruciform (not shown) formed thereon for uniform rupture and ignition.

In the embodiment of igniter **26** shown in the Figures, central electrode **30** optionally includes an extended portion **76** that extends beyond dielectric **38** and conductive body **48**. Extended portion **76** is useful when installing igniter **26** in primer housing **28** of FIG. **2**. While shown as being generally cylindrical, extended portion **76** may also include, for example, a head or widened area formed on its free end to facilitate a larger contact area.

Referring to FIG. **2**, primer housing **28** includes a through-bore **78** having one portion **80** sized for a close tolerance fit with cup **60** and a second portion **82** sized for a clearance fit with extended portion **76** of central electrode **30**. A dielectric or insulating material, for example, plastic, glass, or ceramic, may be inserted between extended portion **76** and second portion **82**. Side **64** of cup **60** forms a metal to metal seal with portion **80**, especially when high pressure gas from the main propellant impinges on respective output ends **34**, **68**, and **70** (FIG. **3**) of central electrode **30**, dielectric **38**, and conductive body **48**. In addition, an aft end **69** of conductive body **48** (see also FIG. **2**) forms a metal to metal seal with housing **28** where through bore **78** transitions or steps down in diameter from portion **80** to portion **82**. Primer housing **28** may include a crimping ring **84** to further seal igniter **26** in primer housing **28**. Other means to secure igniter **26** in primer housing **28** include, for example, retaining sleeves or rings (with or without a shoulder in primer housing **28**), welding, press fit, adhesives, etc.

FIG. **6** is a side sectional view of another embodiment of an EMF hardened electric primer **100** having a primer head assembly **112** and a primer body assembly **114**. Primer body assembly **114** may be threaded into primer head assembly **112**. Primer head assembly includes a housing **128**, a sleeve **116**, and igniter **26**. External threads on sleeve **116** may form a sealed threaded joint **118** with internal threads in the through bore **178** of housing **128**.

Igniter **26** may be press fit in sleeve **116** such that side **64** of cup **60** forms a metal to metal seal with the interior of sleeve **116**, especially when high pressure gas from the main propellant impinges on respective output ends **34**, **68**, and **70** (FIG. **3**) of central electrode **30**, dielectric **38**, and conductive body **48**. In addition, an aft end **69** of conductive body **48** (see also FIG. **2**) forms a metal to metal seal with housing **128** where through bore **178** transitions or steps down in diameter from the portion of housing **128** that contains sleeve **116** to the portion of housing **128** that contains extended portion **76** of central electrode **30**.

Test Results

An igniter **26** was constructed with central electrode **30** made of nickel alloy, dielectric **38** made of Corning Glass No. 9013, and conductive body **48** made of 304L stainless steel. Hot wire **56** was made of Nichrome with a diameter of 2.25 mils and a resistance of 173.0 ohms/foot. Hot wire **56** was welded to central electrode **30** and conductive body **48**. Ignition mixture **58** was made of zirconium potassium perchlorate (ZPP) comprising zirconium 52%, potassium perchlorate 42%, graphite 1%, and Viton® 5%. Cup **60** was made of 304L stainless steel with a cruciform on its top surface for uniform rupture and ignition. Cup **60** was TIG welded to conductive body **48** to provide a hermitic seal and structural integrity.

The igniter **26** survived a ballistic test at 6900 bars (100 ksi). The amounts of electromagnetic field intensity required to exceed the no-fire energy threshold of a prior art igniter and igniter **26** were compared. The tests were conducted at worst case conditions wherein the EMF transmitter was tuned to the natural frequency with a metal object touching the central electrode. The prior art igniter required about 1 mW/cm^2 to exceed the no-fire energy threshold while igniter **26** required about 24.4 mW/cm^2. Igniter **26** displayed a very notable twenty-four fold improvement in the EMF threshold. Igniter **26** may be adapted to function on all electrically fired ammunition to thereby render the ammunition EMF hardened. The function time of igniter **26** was about 2 ms faster than the prior art igniter. Igniter **26** is hermetically sealed, but the prior art igniter relies on the cartridge environment for sealing.

While the invention has been described with reference to certain embodiments, numerous changes, alterations and modifications to the described embodiments are possible without departing from the spirit and scope of the invention as defined in the appended claims, and equivalents thereof.

What is claimed is:

1. An electric and magnetic field hardened igniter for electrically fired ammunition, comprising:

a central electrode having an input end, an output end, and an outer surface;

a dielectric that surrounds the central electrode, the dielectric having an outer surface and an inner surface, the inner surface being contiguous to the outer surface of the central electrode, the outer surface of the central electrode and the inner surface of the dielectric being fixed to each other by at least one mechanical lock wherein the at least one mechanical lock that fixes the outer surface of the central electrode and the inner surface of the dielectric comprises protrusions on the inner surface of the dielectric and corresponding mating circumferential channels in the outer surface of the central electrode;

a conductive body that surrounds the dielectric, the conductive body having an inner surface that is contiguous to the outer surface of the dielectric, the inner surface of the conductive body and the outer surface of the dielectric being fixed to each other by at least one mechanical lock wherein the at least one mechanical lock that fixes the outer surface of the dielectric and the inner surface of the conductive body comprises a stepped down portion on the inner surface of the conductive body and a corresponding mating stepped up portion on the outer surface of the dielectric wherein said mechanical lock is proximal to the hot wire;

at least one hot wire fixed at one end to the output end of the central electrode and at another end to the conductive body;

an ignition mixture in contact with a majority of surface area of the at least one hot wire wherein said ignition mixture comprises zirconium, potassium perchlorate, graphite, and Viton; and

a cup that surrounds and contains the ignition mixture, the cup having an inner surface that is contiguous to the ignition mix, the cup being fixed to the conductive body.

2. The igniter of claim **1**, wherein the central electrode has a generally cylindrical shape, the dielectric has a generally hollow cylindrical shape, and the conductive body has a generally hollow cylindrical shape.

3. The igniter of claim **1**, wherein the at least one hot wire is parallel to a plane that contains the output end of the central electrode.

4. The igniter of claim **3**, wherein the dielectric includes an output end and the conductive body includes an output end, and the hot wire is in contact with the output end of the central electrode, the output end of the dielectric and the output end of the conductive body.

5. The igniter of claim **4**, wherein the hot wire is welded to the output end of the central electrode and the output end of the conductive body.

6. The igniter of claim **3**, wherein the cup includes a bottom and a side, the bottom being parallel to the plane that contains the output end of the central electrode.

7. The igniter of claim **6**, wherein the cup is fixed to the conductive body by welding the side of the cup to the conductive body.

8. A primer head assembly, comprising:

a primer housing; and

the igniter of claim **1** disposed in the primer housing.

9. An electric primer, comprising:

the primer head assembly of claim **8**; and

a primer body assembly fixed to the primer head assembly.

10. An electrically fired munition, comprising:

a case with a base;

the electric primer of claim **9** disposed in the base; and

propellant disposed in the case.

11. An electrically fired munition comprising the igniter of claim **1**.

12. An electric and magnetic field hardened igniter for electrically fired ammunition, comprising:

a generally cylindrical central electrode having an input end, an output end, and an outer surface;

a generally cylindrical, hollow dielectric that surrounds the central electrode, the dielectric having an outer surface and an inner surface, the inner surface being contiguous to the outer surface of the central electrode, the outer surface of the central electrode and the inner surface of the dielectric being fixed to each other by at least one mechanical lock wherein the at least one mechanical lock that fixes the outer surface of the central electrode and the inner surface of the dielectric comprises protrusions on the inner surface of the dielectric and corresponding mating circumferential channels in the outer surface of the central electrode;

a generally cylindrical, hollow conductive body that surrounds the dielectric, the conductive body having an inner surface that is contiguous to the outer surface of the dielectric, the inner surface of the conductive body and the outer surface of the dielectric being fixed to each other by at least one mechanical lock wherein the at least one mechanical lock that fixes the outer surface of the dielectric and the inner surface of the conductive body comprises a stepped down portion on the inner surface of the conductive body and a corresponding mating stepped up portion on the outer surface of the dielectric wherein the at least one mechanical lock is proximal to the hot wire;

a hot wire fixed at one end to the output end of the central electrode and at another end to the conductive body;

an ignition mixture in intimate contact with the hot wire wherein said ignition mixture comprises zirconium, potassium perchlorate, graphite, and Viton; and

a cup that surrounds and contains the ignition mixture, the cup having an inner surface that is contiguous to the ignition mix, the cup being fixed to the conductive body.

13. The igniter of claim **12**, wherein the dielectric includes an output end and the conductive body includes an output end, and the hot wire is in contact with the output end of the central electrode, the output end of the dielectric and the output end of the conductive body.

14. The igniter of claim **13**, wherein the hot wire is welded to the output end of the central electrode and the output end of the conductive body.

15. The igniter of claim **12**, wherein the cup includes a bottom and a side, the bottom being parallel to the plane that contains the output end of the central electrode.

16. The igniter of claim **15**, wherein the cup is fixed to the conductive body by welding the side of the cup to the conductive body.

17. The igniter of claim **12** wherein the at least one mechanical lock that fixes the outer surface of the central electrode and the inner surface of the dielectric comprises protrusions on the inner surface of the dielectric and corresponding mating circumferential channels in the outer surface of the central electrode.

18. The igniter of claim **12**, wherein the at least one mechanical lock that fixes the outer surface of the dielectric and the inner surface of the conductive body comprises a stepped down portion on the inner surface of the conductive body and a corresponding mating stepped up portion on the outer surface of the dielectric.

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